

# **Model Uncertainty in Performance Assessment for the Proposed Yucca Mountain Repository for High-Level Radioactive Waste**

Presented at Workshop on :

**Model Uncertainty: Conceptual and Practical Issues in Risk-Informed Decision Making**

Presented by:

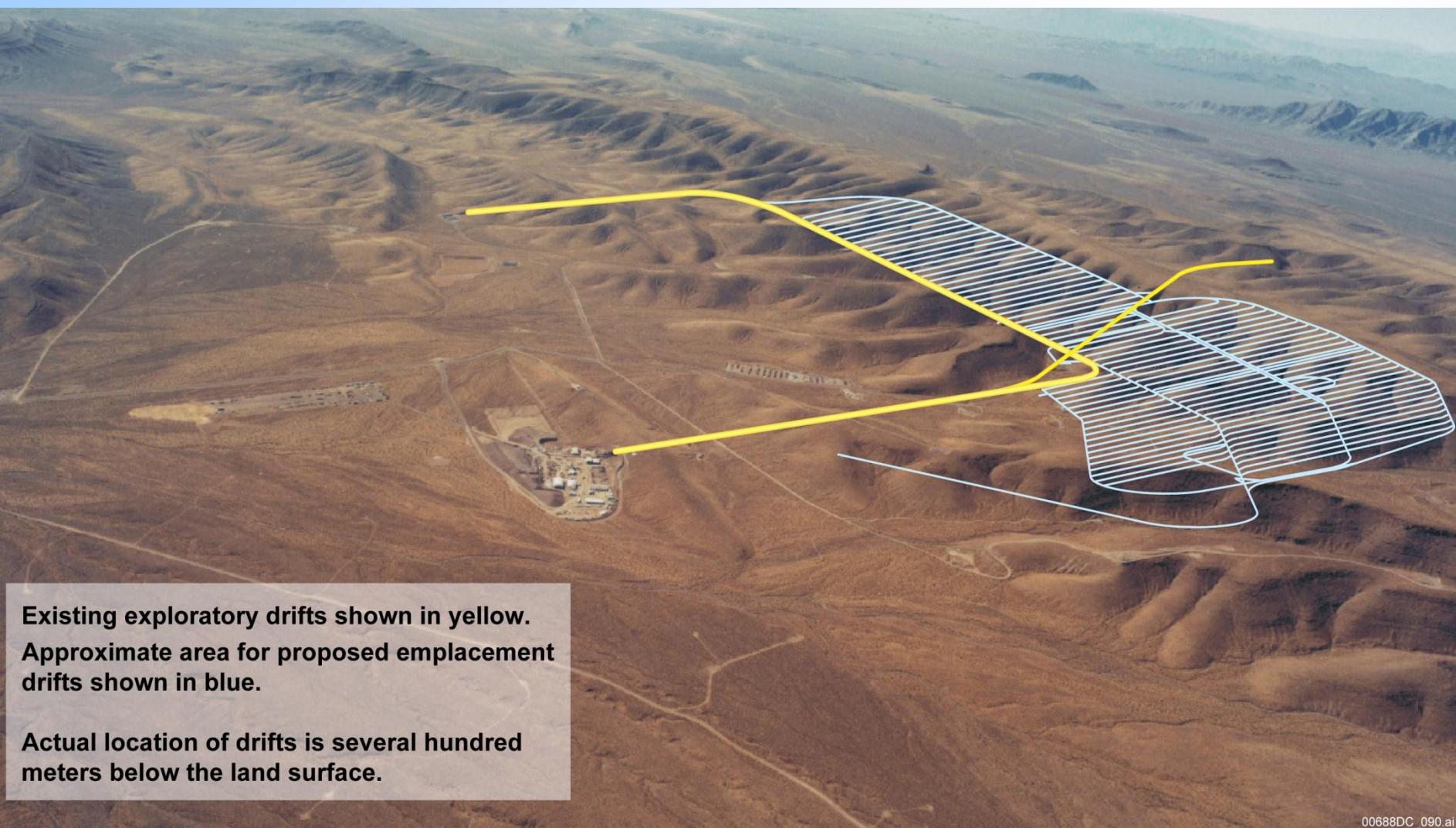
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# Proposed Repository for High-Level Waste and Spent Fuel at Yucca Mountain



Existing exploratory drifts shown in yellow.  
Approximate area for proposed emplacement drifts shown in blue.

Actual location of drifts is several hundred meters below the land surface.

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# **10 CFR 63 and 40 CFR Part 197**

## **Core Regulatory Requirements for YM Repository**

- Maximum value of mean dose to the reasonably maximally exposed individual (RMEI) over time interval  $[0, 10^4 \text{ yr}]$  less than 15 mrem/yr
- Maximum value of mean dose to the RMEI over time interval  $[10^4, 10^6 \text{ yr}]$  less than 100 mrem/yr
- Take uncertainties and gaps in knowledge into account
- Requirements lead to Performance Assessment that
  - Computes measures of performance (e.g. mean dose)
  - Accounts for and quantifies uncertainty in measures of performance

# Four Questions Underlying YM TSPA

*(Yucca Mountain Total System Performance Assessment)*

- Q1: What can happen?
- Q2: How likely is it to happen?
- Q3: What are the consequences if it does happen?
- Kaplan and Garrick “risk triplet”
  - Originated with safety assessments for nuclear power plants
  - Used in performance assessment for Waste Isolation Pilot Plant
  - S. Kaplan and B. J. Garrick, 1981. “On the Quantitative Definition of Risk”, *Risk Analysis*. Vol 1, no 1, 11-27.
- Q4: What is the uncertainty in the answers to the first three questions?

# Mathematical Entities Underlying YM TSPA

## EN1: Probabilistic characterization of what can happen in the future

- Answers first two questions
- Provides formal characterization of aleatory uncertainty

*E.G. Assumption that igneous event occurrence is a Poisson process*

## EN2: Mathematical models for predicting consequences

- Answers third question

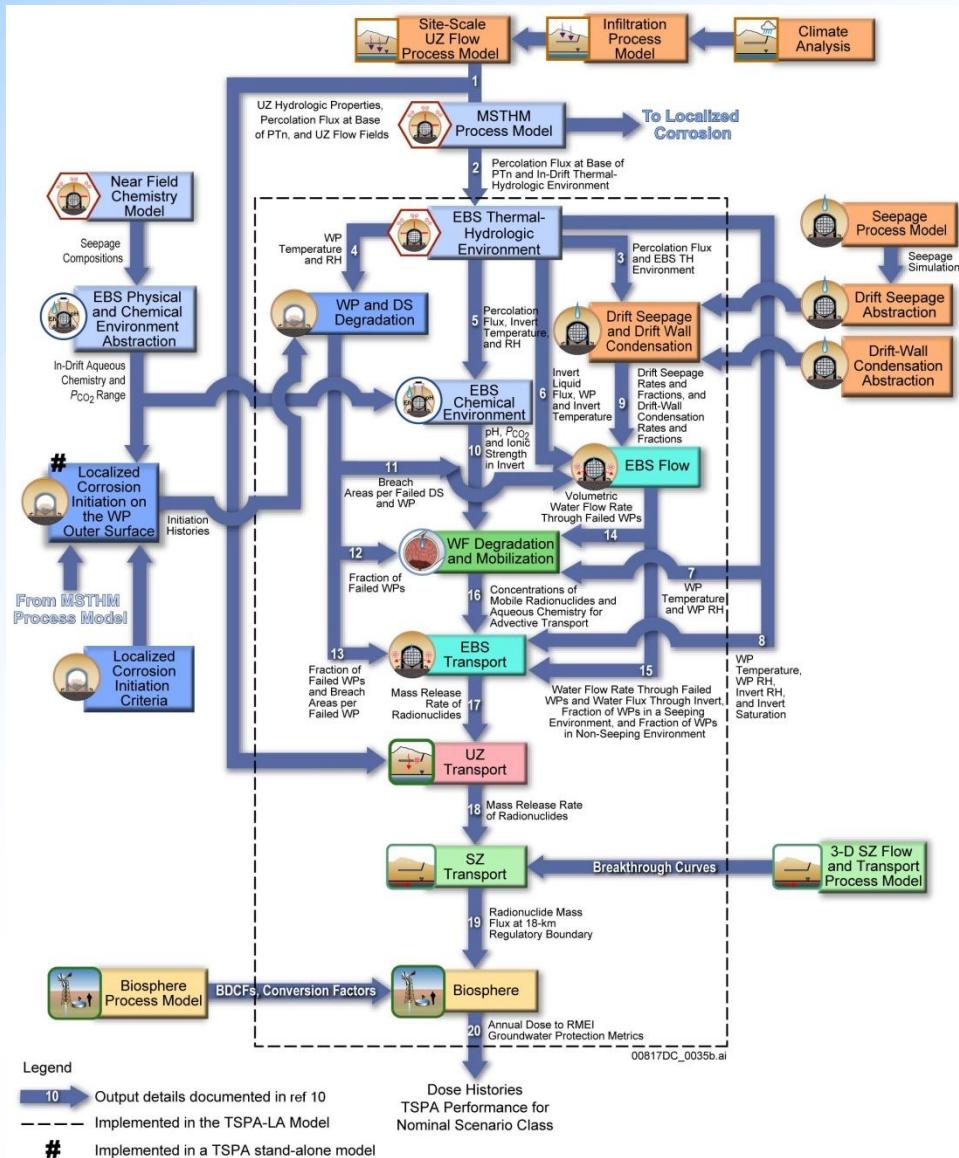
*E.G. Flow and Transport Models*

## EN3: Probabilistic characterization of uncertainty in TSPA inputs

- Basis for answering fourth question
- Provides formal characterization of epistemic uncertainty

*E.G. Distribution assigned to rate for a Poisson process*

# Models for Nominal Scenario Class

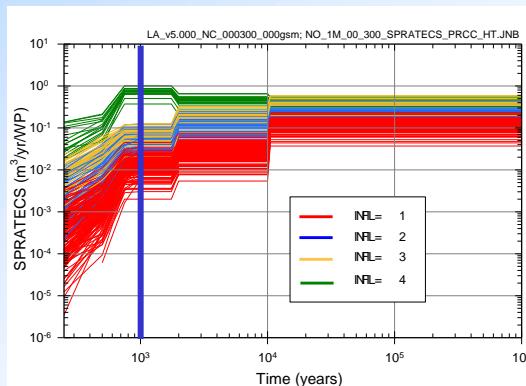


# Model Uncertainty in the 2008 YM PA

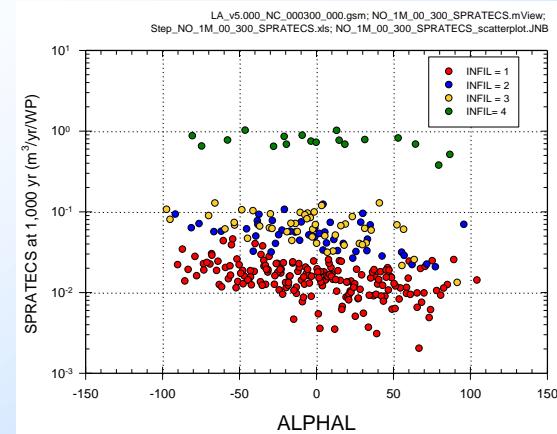
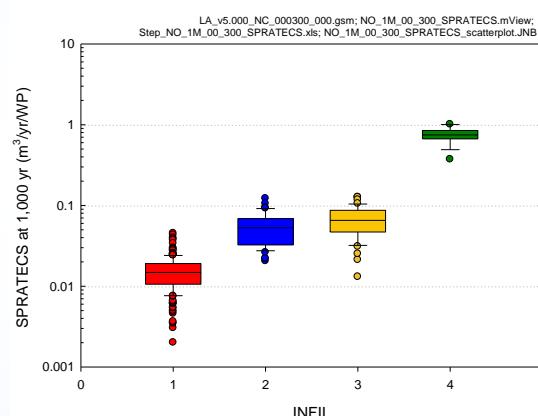
- 392 epistemically uncertain analysis inputs
- No clean line between parameter uncertainty and model uncertainty
- Some Examples follow

# Uncertain Model for Infiltration

- **INFIL** – Pointer variable for four alternative surface infiltration models
- Results in four alternative three dimensional flow fields
- Many effects including: seepage rates ( $\text{m}^3/\text{yr}/\text{WP}$ ) above CSNF WPs in percolation bin 3 under nominal conditions (TSPA AMR Figs K4.3-1, -2)

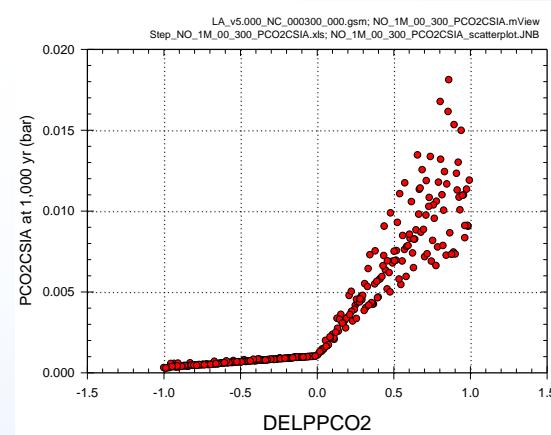
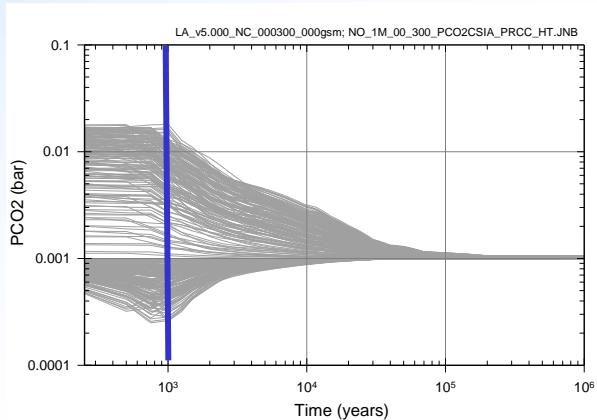


SPRATECS: 1K yr			
Step	Variable	R <sup>2</sup>	SRRC <sup>d</sup>
1	INFIL	0.67	0.83
2	SEEPPRMN	0.76	-0.28
3	ALPHAL	0.82	-0.26
4	SEEPPRM	0.85	-0.19
5	SEEPUNC	0.87	0.15
6	INRFRCTC	0.88	0.06
7	CORRATSS	0.88	-0.05



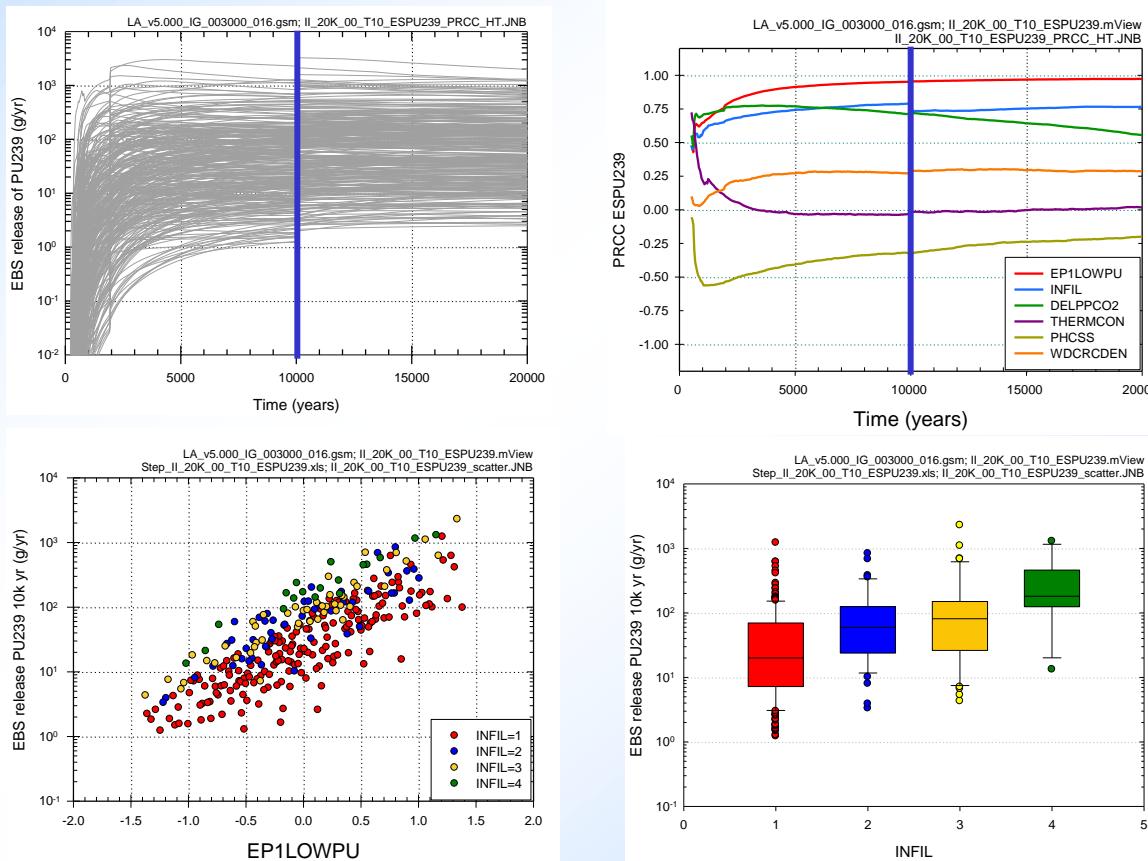
# Uncertain Model for CO<sub>2</sub> Partial Pressure

- **DELPPCO2** – Selector variable for CO<sub>2</sub> Partial Pressure model
  - Uniform on [-1,1], with negative and positive values indicating Mode 1 or 2, respectively
  - |DELPPCO2| scales model results
- Example results: Partial pressure for CO<sub>2</sub> (bars) in invert for CSNF WPs experiencing dripping conditions in percolation bin 3 under nominal conditions (TSPA AMR Figs. K.4.3-7,-8)



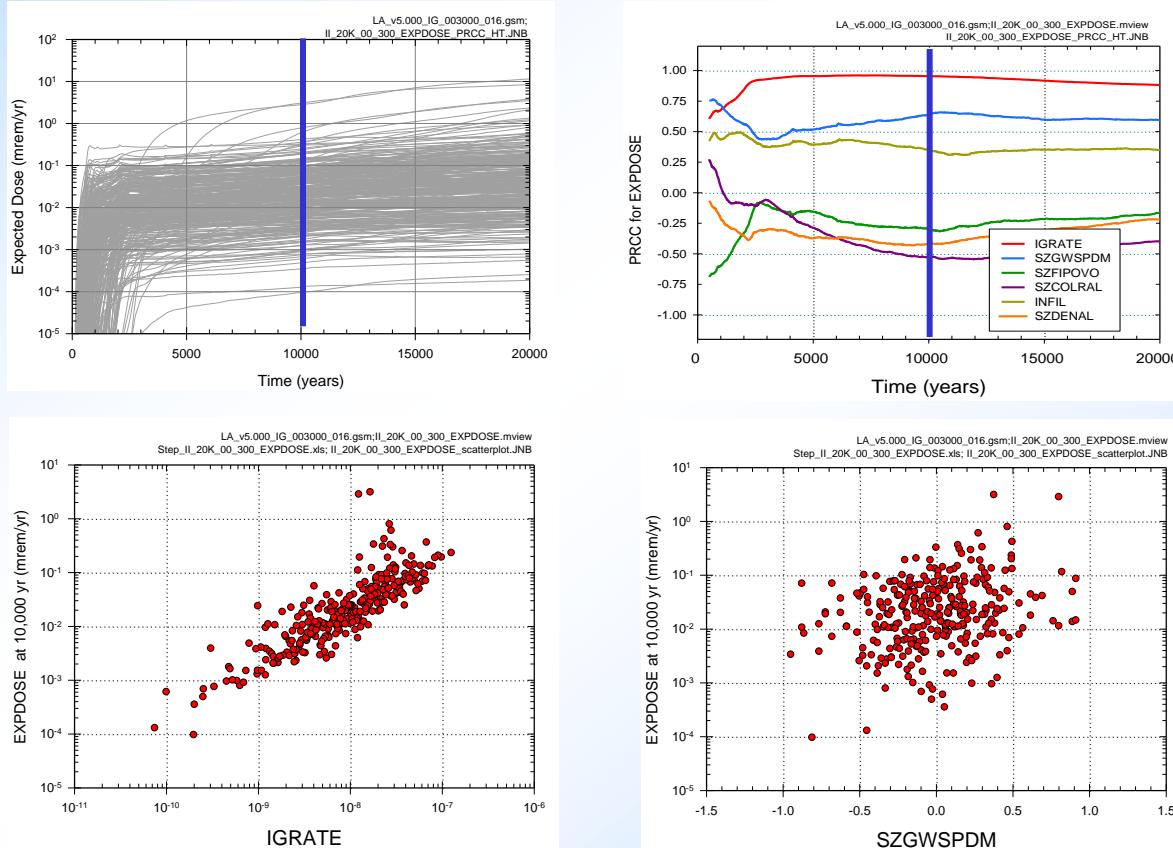
# Uncertain Model for Plutonium Solubility

- **EP1LOWPU** – Logarithm of scale factor for plutonium solubility model under low ionic strength conditions. Distribution: truncated normal on  $[-1.4, 1.4]$  with  $\mu=0.0$  ;  $\sigma=0.7$
- Example results: Release rate (g/yr) of dissolved  $^{239}\text{Pu}$  from EBS for igneous event at 10 yr that destroys all WPs (TSPA AMR Figs K6.3.1-7,-8)



# Uncertain Model for Poisson Process

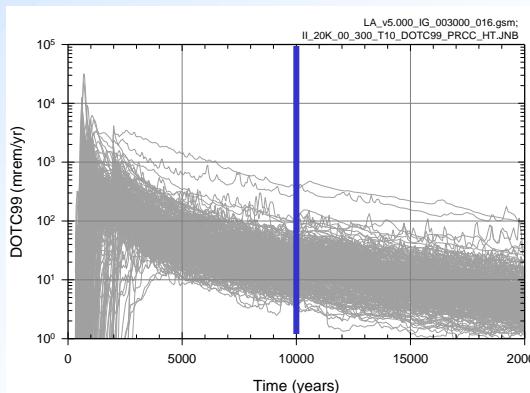
- **IGRATE** – Defining rate ( $\text{yr}^{-1}$ ) for Poisson model for occurrence of igneous events. Piecewise uniform on  $[0, 7.76 \times 10^{-7} \text{ yr}^{-1}]$
- Example: Expected dose (mrem/yr) to RMEI from igneous intrusion (TSPA AMR Figs K6.7.1-1,-2)



More interesting: Uncertain hazard curves

# Uncertain Model for Dose Conversion

- **MICTC99** – Groundwater dose conversion factor ((Sv/yr)/(Bq/l)) for  $^{99}\text{Tc}$ . Discrete from  $[5.28 \times 10^{-6}, 2.85 \times 10^{-4}]$
- Distribution direct result of sampling-based uncertainty analysis for all dose conversion factors
- Example: Dose (mrem/yr) to RMEI from  $^{99}\text{Tc}$  for igneous event at 10 yr that destroys all WPs (TSPA AMR Figs K6.6.1-9,-10)



Step	DOTC99: 10,000 yr		
	Variable	R <sup>2</sup>	SRRC
1	MICTC99	0.29	0.57
2	INFIL	0.47	-0.43
3	SZGWSPDM	0.59	-0.33
4	SZFISPVO	0.64	-0.30
5	CSNFMASS	0.70	0.24
6	SZDIFCVO	0.72	0.13
7	KDRACOL	0.73	0.09

